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U.S. SOIL CONSERVATION SERVICE
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ADVANCE REPORT
on the
SEDIMENTATION SURVEY OF BAYVIEW RESERVOIR
BIRMINGHAM, ALABAMA.

November 30, 1935 - January 25, 1936

by

D. Hoye Eargle and Farrell F. Barnes

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ADVANCE REPORT
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SEDIMENTATION SURVEY OF BAYVIEW RESERVOIR
BIRMINGHAM, ALABAMA

GENERAL INFORMATION

Location: State: Alabama. (See fig. 1)

County: Jefferson.

Township: T. 17 S., R. 4 W., secs. 7, 8, 9, 16, 17, 21,
22, and 23.

Distance and direction from nearest city: About 4 miles
northwest of Birmingham.

Drainage and backwater: The dam is on Village Creek, a
tributary of Locust Fork of the Black Warrior River.
Water is also impounded on Corbet and Camp Branches.

Ownership: Tennessee Coal, Iron, and Railroad Co., Birmingham, Ala.

Purpose served: Industrial water supply.

Description of dam: The dam is a gravity-type structure with a core of cyclopean masonry faced with concrete blocks. It is 106 feet high, 404 feet between abutments, 82 feet thick at the base and about 20 feet thick at the top. The upstream face is nearly vertical. The top of the dam is 508.4 feet above mean sea level and 18.9 feet above spillway crest level.

A concrete spillway, joined to the east abutment of the dam, extends upstream along the valley side approximately perpendicular to the main dam. It is 463 feet long, 8 feet high, and has an ogee section. The spillway crest is 489.5 feet above mean sea level, about 87 feet above the original stream channel at the dam. Overflow from the spillway passes through an artificial channel about 500 feet long into a small tributary valley which joins Village Creek just below the dam.

Prior to 1926, when additions were made, the dam was 15 feet lower than at present, and 4-foot flashboards were used in place of the present 8-foot concrete spillway. The effective crest was therefore 4 feet below its present level. Four sluice gates were built into the dam, two of them at the bottom, but rust and silt accumulation have put them out of operation and they have not been opened in recent years.

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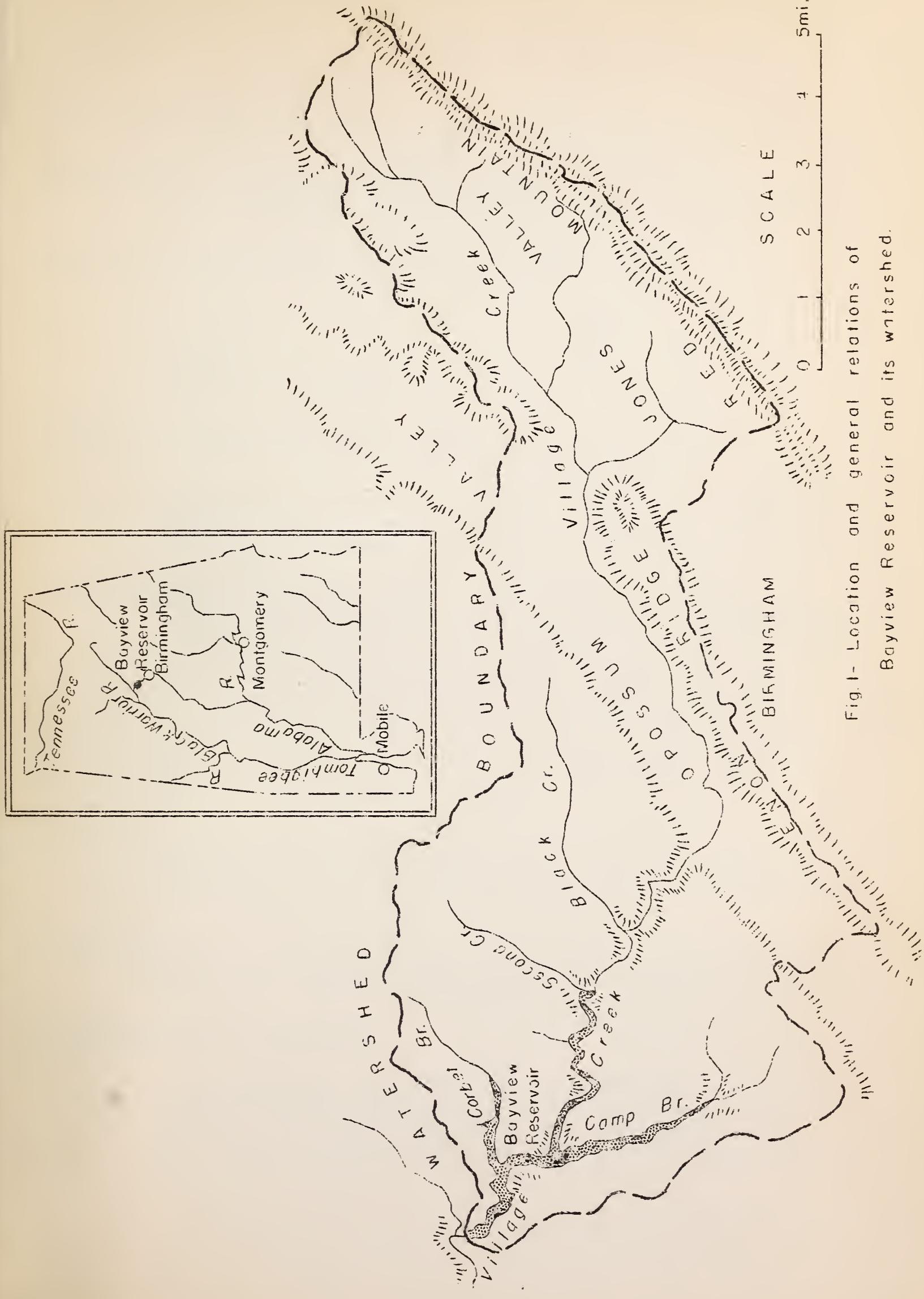


Fig. 1 - Location and general relations of
Bayview Reservoir and its watershed.

Date of completion: May 1911.

Average date of survey: December 1935. Age: 24.6 years.

Length of lake (original and present): 6.7 miles from the dam to the head of backwater on Village Creek. Length of Corbet Branch arm: 1.6 miles. Length of Camp Branch arm: 1.4 miles.

Area of lake at crest stage: (determined by this survey)

	<u>Acres</u>
Original.....	478.5
Present.....	424.4
Reduction by silting.....	54.1

Storage capacity at crest stage: (determined by this survey)

	<u>Acre-feet</u>	<u>Gallons</u>
Original.....	11,866	3,866,536,100
Present.....	9,514	3,100,136,900
Reduction by silting.....	2,352	766,399,200

General character of reservoir basin: Bayview Reservoir is long and narrow (fig. 2 in pocket), lying in a stream valley deeply incised in the Cumberland Plateau. In the lower 5 miles of its length the basin is canyonlike, with valley walls rising almost vertically from a narrow flood plain. Toward their heads the valleys of Village Creek and Camp Branch broaden to widths of 1,000 feet or more, although the impounded water in these reaches, particularly on Village Creek, does not extend far beyond the limits of the main channel, which is generally less than 100 feet wide.

The average original gradient from the head of the Village Creek arm to the dam was about 13 feet per mile. Prior to submergence there was a distinct rapids, known as Village Falls, in Village Creek at the mouth of Camp Branch.

Area of watershed: 72.3 square miles, as planimetered from topographic maps of the Birmingham Coal District and Bessemer Iron District quadrangles, editions of 1906 and 1907, respectively.

General character of watershed:

Physiography:- The Bayview watershed extends with a roughly crescent-shaped outline from about 3 miles northeast of Eastlake, the northeastern extension of Birmingham, to the dam, 6 miles beyond the northwest limits of Birmingham (fig. 1). The watershed consists of three distinct units:

(1) An eastern (Jones Valley) section, averaging about 8 miles long by 3 miles wide, which is bordered on the southeast by a prominent northeastward-trending ridge known as Red Mountain. On the west it is bordered by a lower parallel ridge which separates it from

(2) a central (Opossum Valley) section, averaging 5 miles long by 1 mile wide, which flanks

(3) a western Plateau section, averaging 6 miles long by 5 miles wide, in the hilly country west of Birmingham.

Sections 1 and 2 lie in the Cahaba Ridges section of the Valley and Ridge Province, and section 3 is a part of the Cumberland Plateau section of the Appalachian Plateau Province.

Topography:- The eastern half of the watershed is characterized by broad, flat-bottomed valleys bordered by steep-sided ridges. Red Mountain on the southeast rises 500 to 600 feet above the floor of Jones Valley in a horizontal distance of less than a mile. The discontinuous ridge which separates Jones and Opossum Valleys averages less than 200 feet in height.

The western half of the area lies in typical dissected plateau country with a well-developed drainage pattern and an average relief of about 200 feet.

The average gradient of Village Creek, from the point where it enters Jones Valley to the head of the reservoir, is approximately 12 feet per mile.

Geology:- The two eastern sections of the watershed, including about half of the drainage area, are underlain in large part by Cambrian and Ordovician limestone and dolomite and to a lesser extent by Silurian and Mississippian sandstone and shale. These rocks have been extensively thrust-faulted and warped into northeastward-trending folds with moderate to nearly vertical dips. The western or Plateau section lies on almost horizontal, slightly faulted Pennsylvanian (Pottsville) shale and sandstone strata, which contain several important seams of coal.

Soils:- The principal soil types of the Bayview watershed, with the source, occurrence, and relative extent of each, are given in table 1, based on a report on the soils of Jefferson County.^{1/} The Decatur and Hagerstown groups, representing the product of chemical decay of probably many hundreds of feet of limestone rock, include the deepest and most fertile soils of the watershed. The Dekalb soils, which cover most of the Plateau section, are relatively thin and highly susceptible to erosion.

1/

Smith, H. C., and Pace, E.S., Soil survey of Jefferson County, Alabama (with map): U.S. Dept. Agr., Bur. of Chem. and Soils. Field operations of the Bureau of Soils, 1908. (Published 1911).

Table 1.- Soils of the Bayview watershed.

Soil	Parent material	Occurrence	Relative Extent (Percent)
<u>Cahaba Ridges section:</u>			
Decatur clay loam.....	Shale and dolomite..	Rolling valleys	9.0
Hagerstown loam.....	Shale and dolomite..	Rolling valleys	9.0
Hagerstown stony loam..	Shale and cherty.... dolomite.	Foothills of... Jones and O- possum Valleys	3.0
Clarksville stony loam.	Dolomite and chert..	Ridges and..... knolls.	18.0
Conasauga clay.....	Limestone and shale.	Jones and Opos- sum Valleys.	6.9
Upsher loam.....	Ferruginous sand-... stone.	Top of Red..... Mountain.	0.4
Huntington silt loam...	Alluvium.....	Stream valleys.	1.0
Huntington gravelly loam	Alluvium with	Stream valleys. chert from the Clarksville.	3.0
Wabash clay.....	Alluvium.....	Stream valleys.	0.8
Rough stony land.....	Limestone, chert, and sandstone.	Steep slopes...	0.5
<u>Plateau section:</u>			
Dekalb silt loam.....	Shale and sand-.... stone.	Flat to gently. rolling land.	36.2
Dekalb fine sandy loam.	Shale and sand-.... stone.	Level to gently rolling up- lands.	2.9
Dekalb shale loam.....	Shale.....	Hilly or roll- ing surfaces.	9.3
			100.0

Erosion conditions:- In most of the eastern (Cahaba Ridges) section of the watershed, erosion is moderate, owing to three factors: (1) Most of the land has gentle slopes. (2) The soils in general are absorbent and nonerodible. (3) Land use for the most part is of a type not conducive to accelerated erosion. In Jones and Opossum Valleys the slope rarely exceeds 5 percent, and the land is either well sodded or in well-developed urban properties. The slopes of the ridges bordering the valleys are either forested or included in valuable residential suburbs. Exceptions to the characteristically moderate erosion of this part of the watershed occur only in a limited area along the crest of Red Mountain, where iron-mining operations have accelerated erosion to a marked degree.

The western (Plateau) section of the watershed is characterized by severe sheet, rill, and gully erosion. In some places severe erosion has been under way for a long time, but over much

of the area it has been recently induced by the cutting of vast tracts of woodland and the conversion of the cleared land into gardens without protection by terraces or other erosion-control methods. These factors, together with the prevailingly steep slopes, and the highly erodible character and shallow depth of the soils of this section, have produced an erosion hazard which threatens the complete destruction of the surface soil. Deep gullies are rare because of the shallow depth of surface soil over the underlying bedrock, but hillsides so rilled as to resemble a corrugated metal barn roof are not uncommon. Much of the area not yet gullied is being rapidly stripped of its soil by sheet erosion.

Land use.--The watershed area is devoted to different land uses in approximately the following proportions:

	<u>Percent</u>
Urban developments.....	50
Forests.....	25
Cultivated (chiefly truck crops)	15
Pasture.....	10

Forest: The broad valley lands of the watershed, where the soils are residual after limestone, were once covered with a heavy growth of cedar, longleaf pine, and various hardwoods. Later, because of their fertile soil and favorable topography, these lands were extensively cleared and planted to crops. With the growth of Birmingham as an industrial center, however, most of the valley land was occupied by industrial and residential developments. At this date practically none of the valley land remains in forest.

The low ridges within the valleys were once forested, chiefly with longleaf pine and hardwoods, but these forests were exploited for lumber and have been replaced by second-growth scrub oaks with some inferior shortleaf pine. Most of these areas are now partly developed as residential districts, so that actually little woodland remains.

On the western slopes of Red Mountain and its foothills much of the original forest remains and is now included in restricted suburban developments and large estates. These forests are principally oak, longleaf and shortleaf pines, hickory, and gum.

In the western half of the watershed the original forests were principally longleaf pine, but these have been exploited and sup-planted by a mixture of oaks, shortleaf pine, and second-growth longleaf pines. About 1932 most of the forests on the western up-lands were cleared, so that the only remaining large woodland areas are on the rugged land in the immediate vicinity of Bayview Reservoir.

Pasture: Most of the alluvial flood plain of Village Creek, representing about 10 percent of the watershed, is in pasture or

grassland. The high run-off from the city streets has, in the past, caused extensive flooding of the area below the main part of the city. Recently this situation has been partly relieved by extensive dredging of the Village Creek channel from the lower sections of the city almost to the head of Bayview Reservoir. Immediately above the reservoir some extensive grassland remains, which supports a part of the local dairying industry. In the upper end of the watershed a part of this low-lying grassland is included in a large municipal park and recreation center.

Urban developments: Approximately half of the watershed of Bayview Reservoir is in the highly industrialized city of Birmingham and its suburbs and numerous mining settlements scattered over the plateau to the west. The industrial and business districts, as well as many of the suburban residential districts, are concentrated in Jones and Opossum Valleys.

Mean annual rainfall: 49.48 inches at Birmingham.

Inflow into reservoir: No gaging records of Village Creek or its tributaries are available. Village Creek receives a large part of the fluid sewage from the city of Birmingham. The water supply of the city comes from the Cahaba River to the southeast, so that the sewage entering Village Creek is an artificial auxiliary to the natural run-off from the Bayview watershed.

Draft on reservoir:

	<u>Gallons per month</u>
Present average:	
Summer.....	900,000,000
Rest of year.....	750,000,000

Maximum (1926, 1927):	
Summer and fall.....	1,500,000,000 +
Rest of year.....	1,400,000,000 +

Water for industrial plants is pumped from the reservoir by way of a tunnel with intake in Camp Branch about 2,000 feet above its junction with Village Creek.

HISTORY OF SURVEY

The sedimentation survey of Bayview Reservoir was made during the period November 30, 1935 to January 25, 1936 by the Southeastern Reservoir Party, Section of Hydrodynamic Studies, Division of Research. The personnel consisted of L. M. Seavy, party chief, G. A. Zwerner, assistant chief, E. H. Moser, Jr., W. G. Shannon, George Sohn, and A. B. Taylor. During the survey Mr. Shannon was transferred to another party and replaced by M. P. Connaughton, and Mr. Zwerner was called to the Washington Office and replaced by L. C. Gottschalk. Arrangements for the survey, a study of sedimentation in the reservoir, and a reconnaissance examination of erosion conditions in the watershed were made by D. H. Eargle.

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Original and present capacities and silt volumes were determined from the head of the Corbet Branch arm to the dam (fig. 2, in pocket) by the range method, and above the mouth of Corbet Branch, including the Camp Branch arm, by the contour method.^{2/} Thirty-four ranges were sounded and spudded in surveying 198 acres by the range method, and 163 ranges were sounded in mapping 226 acres by the contour method.

A map of the original reservoir basin, on a scale of 200 feet to the inch and with 5-foot contours, was used as a base for all surveying and also to determine the original capacity of the part of the reservoir surveyed by the contour method. Horizontal control was checked in wider sections of the reservoir by triangulation nets expanded from chained base lines and in narrower sections by tying-in with various land and section corners shown on the original map. All mapping, including triangulation, location of ranges by stadia, location of points on ranges by intersection, and shore-line mapping, was done by plane table and telescopic alidade on a scale of 200 feet to the inch. A transit was used to keep the boat on range during sounding and spudding operations. The elevations of range ends were determined by leveling from the water surface of the reservoir, the elevation of which was computed from hourly gage readings.

ACKNOWLEDGMENTS

The Soil Conservation Service acknowledges the assistance and cooperation of various officials of the Tennessee Coal, Iron, and Railroad Co. L. McHugh, superintendent of the central waterworks, and F. M. Joy, manager of the land department, furnished information on the reservoir and watershed and placed the facilities of the company at the disposal of the party during the survey. A. J. Blair, geologist, supplied information on the geology of the drainage area.

SEDIMENT DEPOSITS

Character of sediment: The texture of the sediment in Bayview Reservoir shows all gradations from coarse gravelly sand in the upper parts of the principal arms to extremely fine silty clay in the lower reaches. The gravelly material consists principally of shale fragments and coarse chert sand, with some quartz sand, which is carried into the reservoir as bed load during floods. During periods of low inflow deposition of coarse sediment near the head of backwater, particularly on Camp Branch, gives way to the accumulation of exceedingly fine mud which remains for some time in a state of semisuspension. Such accumulations outwardly resemble ordinary mud bars but are sufficiently fluid to permit a boat to pass through them. This sediment eventually settles to form a more or less compact layer of very fine mud. The final deposits in the upper part of the reservoir consist, therefore, of alternating layers of

^{2/}

Eakin, H.M., Silting of reservoirs: U. S. Dept. Agr. Tech. Bull. 524, pp. 129-157, 1936.

coarse and fine sediment. These stratified deposits grade downstream into sandy silt, silt, and finally into silty clay. Below the mouth of Camp Branch the sediment shows little variation in texture. At the surface it is extremely soft, but at depth it is more compact, although the 10-foot spud could easily be plunged to its full length into the deeper deposits.

The color of the silt is prevailingly black, except for occasional gray streaks in the surface layer. The black color is probably due to ferrous sulphide, resulting from the interaction of iron salts from the iron works in the watershed and hydrogen sulphide from decaying organic matter in the sewage discharged into Village Creek.^{3/} The coarse delta deposits and near-crest silt deposits, which are frequently exposed to aeration, are generally light gray.

A sample of the black silt was collected from mid-lake opposite the mouth of Camp Branch, and, after drying for two weeks, was submitted to W. C. Barton, chemist of the Ensley sewage disposal plant, for determination of the organic content. A proximate analysis gave the following results:

	<u>Percent</u>
Moisture.....	28.00
Volatile matter.....	7.49
Ash.....	<u>64.51</u>
	100.00

The percentage of volatile matter is an approximate index of the organic content.

Distribution of sediment: In the contoured section of the reservoir (above Corbet Branch), a study of silt volumes by contour intervals reveals that more than 65 percent of the total sediment in this section lies between the 470 and 489.5 (crest) contours, that about 27 percent lies between the 450 and 470 contours, and that only 7.35 percent lies between the 430 and 450 contours. This indicates, in view of the channel character of the reservoir, that deposition has been heaviest near the heads of the Camp Branch and Village Creek arms and becomes progressively lighter downstream. The distribution of sediment in the contoured section is further illustrated in figures 3 and 4. Figure 4 also shows that all the capacity below the 435 contour has been lost through silting, and that the amount of depletion diminishes at a uniformly decreasing rate from 93 percent at the 440 contour to 41.5 percent at crest level (489.5).

In the range-surveyed section (head of Corbet Branch arm to the dam) the average silt thickness increases in general from 0.2 foot in segment

3/

This is probably a common manner of formation of ferrous sulphide. See Twenhofel, W. H., and others, Treatise on sedimentation. 2d ed., pp. 449-452, Baltimore, Williams and Wilkins Co., 1932.

35 (fig. 2, in pocket) to a maximum of 3.8 feet in segments 19 and 21, at the junction of the Corbet Branch and Village Creek arms, and then decreases to about 2 feet near the dam.

The relative distribution of sediment between the two sections of the reservoir is brought out in table 2. This table shows that the range section, although it embraces 61 percent of the original capacity of the reservoir, has received only about 18 percent of the total sediment, entailing a loss of only 5.8 percent of its original capacity, compared to a 41.5 percent loss for the contoured section.

Table 2.- Capacities and sediment volumes of the upper (contoured) and lower (range-surveyed) sections of Bayview Reservoir

	Original capacity (Acre-feet)	Present capacity (Per-cent)	Sediment (Acre-feet)	Capacity loss (Per-cent)
Range section.....	7,216	60.8	6,795	71.5
Contoured section...	<u>4,650</u>	<u>39.2</u>	<u>2,719</u>	<u>28.5</u>
Total reservoir.....	11,866	100.0	9,514	100.0
			421	17.9
			1,931	82.1
			2,352	100.0
				5.8
				41.5
				19.8

Two special features of sediment distribution are strikingly illustrated in Bayview Reservoir. The first consists of the occurrence of elongated crescentic bars of silt and sand, and depressions of similar outline, in the Village Creek arm above Camp Branch (fig. 5, in pocket). Both occur invariably at stream bends, the bars near the convex side of the channel and the depressions near the concave side either directly opposite or slightly downstream from the bars. In the narrower upper reaches of the Village Creek arm long narrow depressions occur without associated bars. All the bars, with the exception of the one at the first bend above Camp Branch, have been built slightly above spillway crest level. In most cases a shallow back-channel has been maintained between the bar and the main shore, so that the bars appear at crest stage as crescentic islands (fig. 6A). A single exception is the large bar opposite range end R-170, which is tied to the shore at its upstream end. These sand and silt bars are believed to have originated in the same manner as natural levees along a normal stream channel. They resemble levees in cross section, being highest near the channel and sloping gently toward the valley side.

A second noteworthy feature of sedimentation is the partial or complete blocking of the mouths of small tributaries above Camp Branch by sediment accumulations. In figure 5, the closed contours in several small re-entrants indicate the presence of bars across the mouths of tributary arms. These bars were formed by deposition, influenced by the slack water in the arms, of sediment carried down Village Creek. Two tributaries, opposite range ends R-171 and R-173, respectively, were completely cut off from the main reservoir by bars and are now connected with it by small artificial channels.

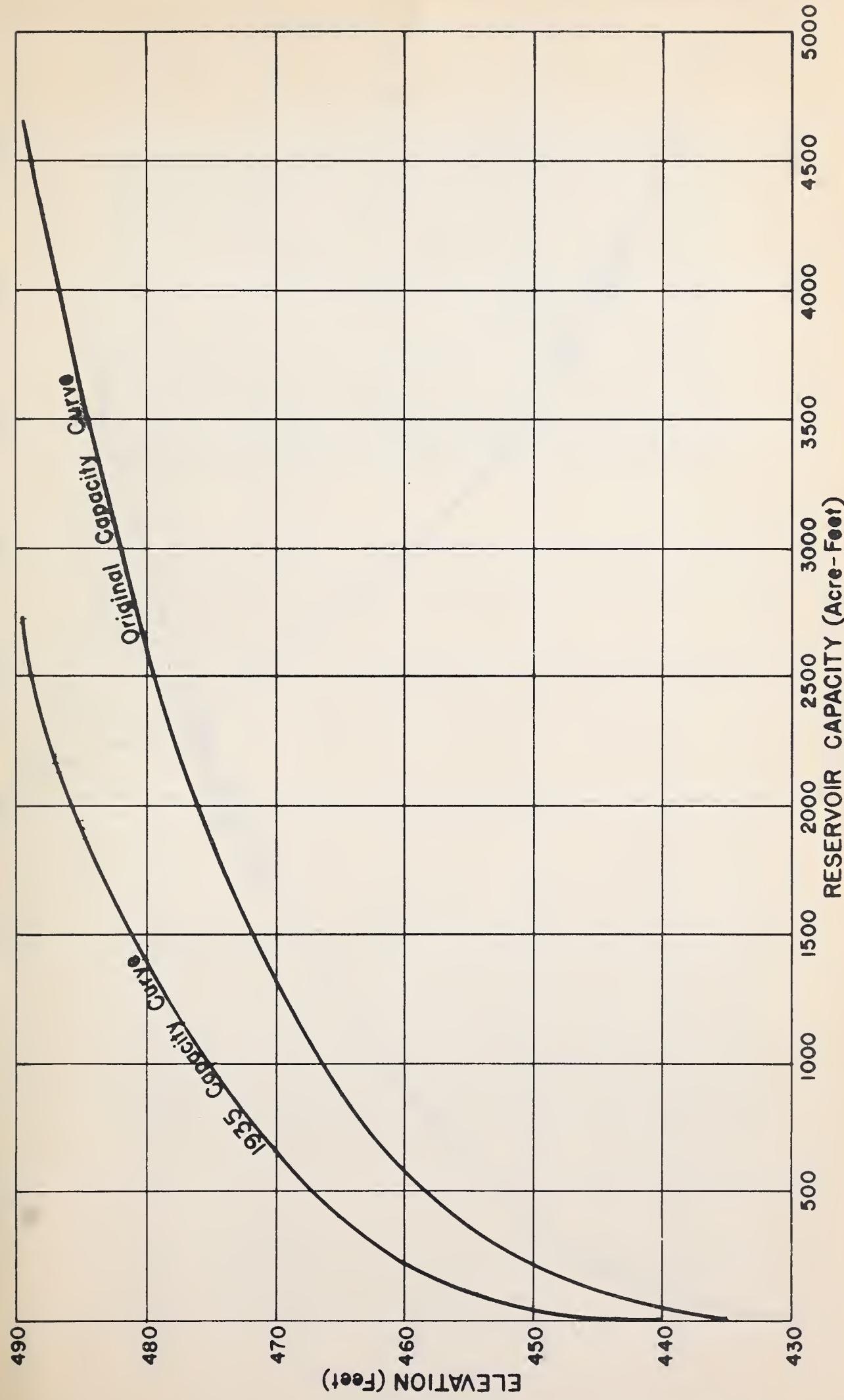


Figure 3 Storage capacity of Bayview Reservoir (contoured section)

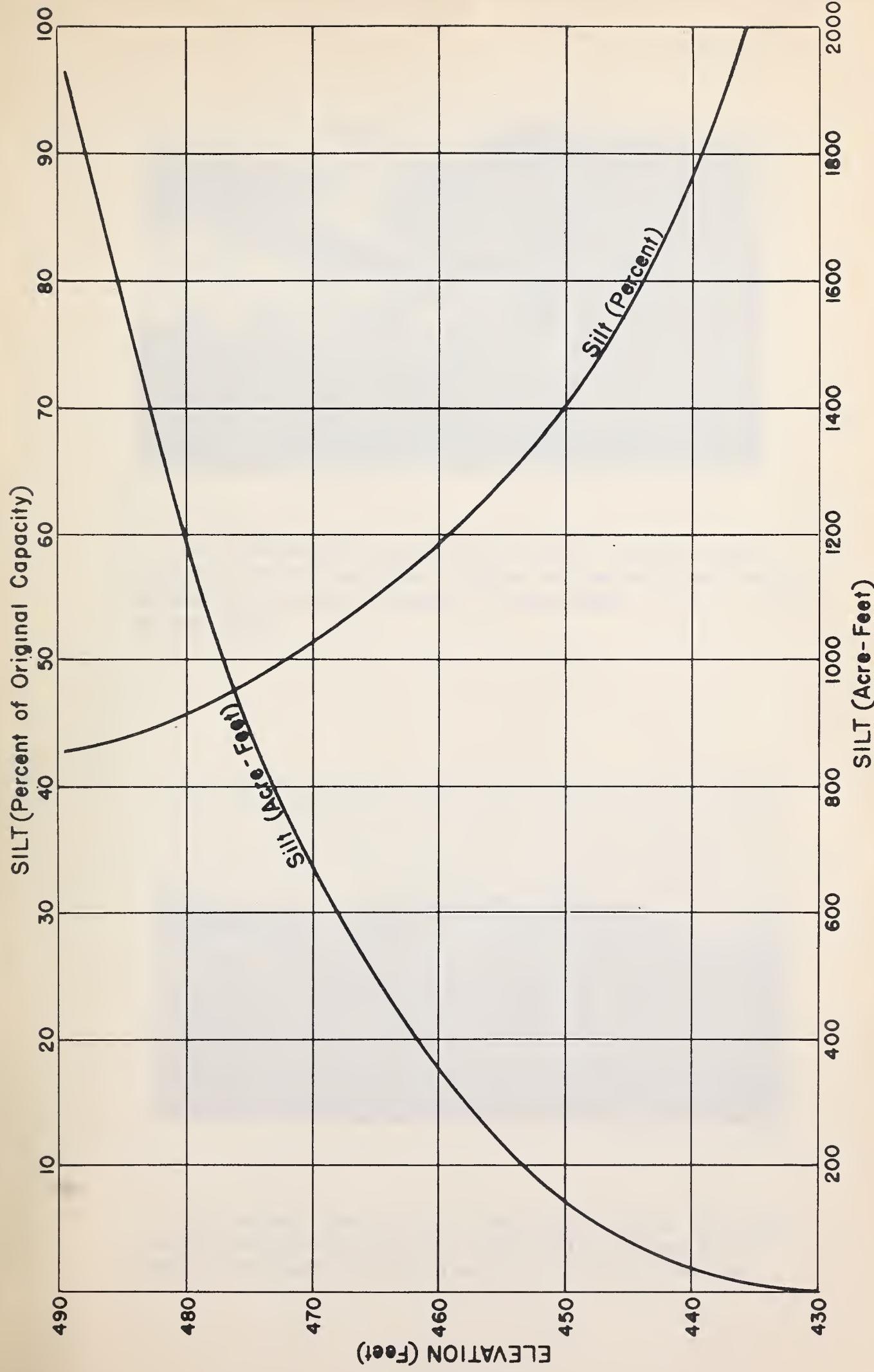


Figure 4 Distribution of silt deposits in Bayview Reservoir (contoured section)

Figure 6.



A. Crescentic silt island in the Village Creek arm of Bayview Reservoir. Note the back-channel maintained by scouring action of flood waters on the inside of the bend.



B. Refuse dump of the Docena coal mine, near the head of Bayview Reservoir. The Village Creek arm is just to the left of the area shown in the picture.

The only true delta in Bayview Reservoir occurs at the head of the Camp Branch arm. A widened section of valley above a narrow constriction has acted as a settling basin, in which several feet of extremely soft oozy sediment has accumulated. Above-crest deposits have decreased the length of open water in this arm about half a mile. Although the Corbet Branch arm has been shortened about 1,000 feet by sedimentation the original basin was so shallow near the head of backwater that this shortening was accomplished by the accumulation of less than a foot of sediment.

No measurable shortening of the Village Creek arm has taken place, because the extremely narrow basin maintains strong inflow currents far down the reservoir, particularly during floods. Although most of all but the finest incoming sediment is deposited in upper reaches during periods of low or moderate inflow, much of this deposited material is picked up by the first flood and redeposited farther downstream. Definite proof of such scouring action was obtained during a January freshet. Before the storm the channel opposite stations R-176 and R-178 was too shallow to permit a motor-boat to pass, but during the freshet the bottom could not be touched with a 7-foot oar, although the water level had risen only about 1 foot at the time of the second observation. The depth of scour at this point was thus at least 4 feet.

Origin of sediment: The sediment in Bayview Reservoir was derived chiefly from sheet, rill, and gully erosion of the soils of the watershed and to a lesser extent from the refuse dumps of several large coal mines. Sewage from the city of Birmingham has contributed a relatively small portion of the total volume, but, as previously stated, is believed to be partly responsible for the dark color of the finer sediment.

The highly erodible Dekalb soils in the hilly country immediately surrounding the reservoir have undergone the most severe erosion occurring in the watershed and have therefore probably contributed the larger part of the reservoir sediment. This aggravated erosion condition, as described above, is due largely to recent deforestation and cultivation of steep slopes.

A considerable but indeterminate part of the storage capacity of the reservoir is thought to have been displaced by debris washed from the dumps of the several coal mines in the watershed. This material is in an ideal condition for rapid erosion, so that the run-off from each rain transports appreciable quantities to the drainage lines and thence into the reservoir. The extent to which these mine dumps are being eroded is indicated in figure 6B.

The following tabulation gives a summary of data relating to Bayview Reservoir, Birmingham, Ala.:

	<u>Quantity</u>	<u>Unit</u>
<u>1/</u> <u>Age</u>	24.6	Years
<u>Watershed:</u>		
Total area.....	72.3	Sq. Mi.
<u>Reservoir:</u>		
Original area at crest stage.....	478.5	Acres
Present area at crest stage.....	424.4	Acres
Original storage capacity.....	11,866	Acre-feet
Present storage capacity.....	9,514	Acre-feet
Original storage per square mile of drainage area.....	164.11	Acre-feet
Present storage per square mile of drainage area.....	131.59	Acre-feet
<u>Sedimentation:</u>		
Delta deposits).....	Not measured separately	
Bottomset beds)		
Total sediment.....	2,352	Acre-feet
Accumulation per year average.....	95.61	Acre-feet
Accumulation per year per 100 square miles drainage area.....	132.24	Acre-feet
Accumulation per year per acre of drainage area.....	90.01	Cubic feet
Or, assuming average weight of 1 cubic foot of silt is 100 lbs.	4.5	Tons
<u>Depletion of storage:</u>		
Loss of original capacity per year....	0.81	Percent
Loss of original capacity to date of survey.....	19.82	Percent

1/ Storage began: May 8, 1911.

Date of survey: November 26, 1935 to January 25, 1936.

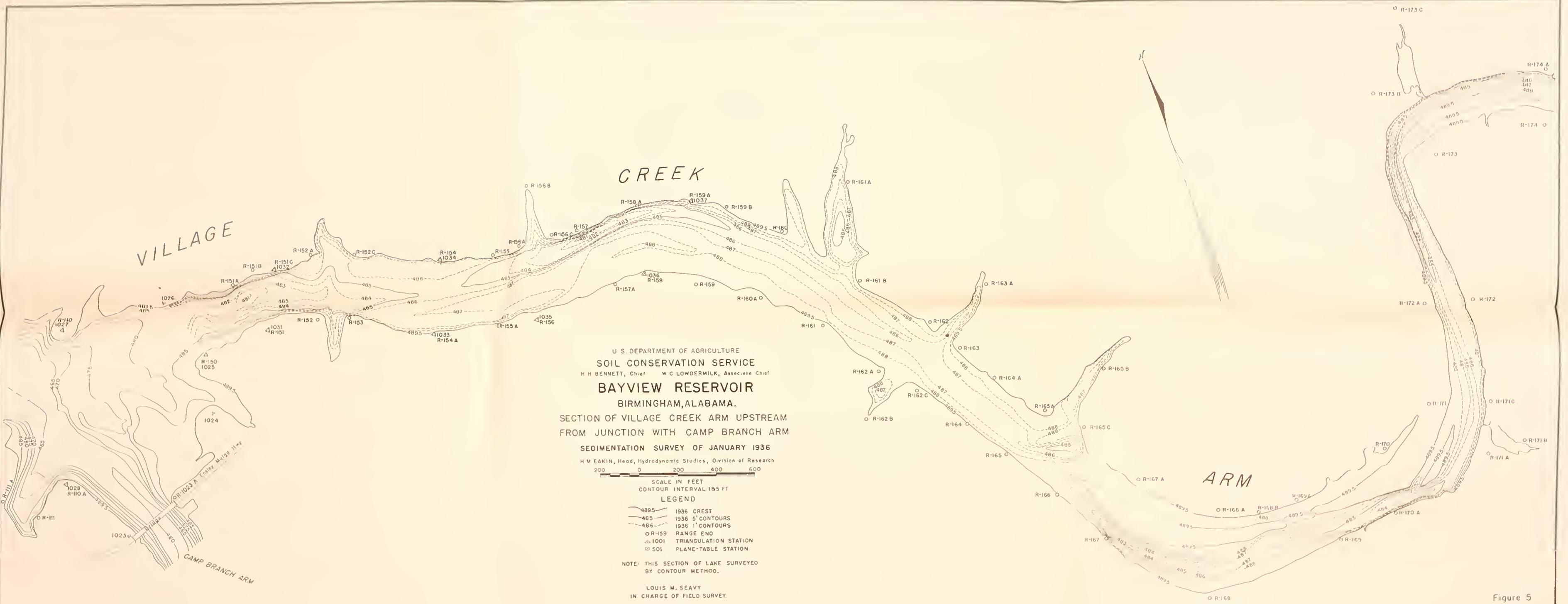




Figure 2

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Report on sedimentation surveys... 11.

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